

after initial installation and after major maintenance.

(b) *Measurement principles.* A chiller removes H<sub>2</sub>O, which can otherwise interfere with a NO<sub>x</sub> measurement. However, liquid H<sub>2</sub>O remaining in an improperly designed chiller can remove NO<sub>2</sub> from the sample. If a chiller is used without an NO<sub>2</sub>-to-NO converter upstream, it could remove NO<sub>2</sub> from the sample prior NO<sub>x</sub> measurement.

(c) *System requirements.* A chiller must allow for measuring at least 95% of the total NO<sub>2</sub> at the maximum expected concentration of NO<sub>2</sub>.

(d) *Procedure.* Use the following procedure to verify chiller performance:

(1) *Instrument setup.* Follow the analyzer and chiller manufacturers' start-up and operating instructions. Adjust the analyzer and chiller as needed to optimize performance.

(2) *Equipment setup and data collection.* (i) Zero and span the total NO<sub>x</sub> gas analyzer(s) as you would before emission testing.

(ii) Select an NO<sub>2</sub> calibration gas, balance gas of dry air, that has an NO<sub>2</sub> concentration within ±5% of the maximum NO<sub>2</sub> concentration expected during testing.

(iii) Overflow this calibration gas at the gas sampling system's probe or overflow fitting. Allow for stabilization of the total NO<sub>x</sub> response, accounting only for transport delays and instrument response.

(iv) Calculate the mean of 30 seconds of recorded total NO<sub>x</sub> data and record this value as  $x_{\text{NOxref}}$ .

(v) Stop flowing the NO<sub>2</sub> calibration gas.

(vi) Next saturate the sampling system by overflowing a dewpoint generator's output, set at a dewpoint of 50 °C, to the gas sampling system's probe or overflow fitting. Sample the dewpoint generator's output through the sampling system and chiller for at least 10 minutes until the chiller is expected to be removing a constant rate of H<sub>2</sub>O.

(vii) Immediately switch back to overflowing the NO<sub>2</sub> calibration gas used to establish  $x_{\text{NOxref}}$ . Allow for stabilization of the total NO<sub>x</sub> response, accounting only for transport delays and instrument response. Calculate the mean of 30 seconds of recorded total

NO<sub>x</sub> data and record this value as  $x_{\text{NOxmeas}}$ .

(viii) Correct  $x_{\text{NOxmeas}}$  to  $x_{\text{NOxdry}}$  based upon the residual H<sub>2</sub>O vapor that passed through the chiller at the chiller's outlet temperature and pressure.

(3) *Performance evaluation.* If  $x_{\text{NOxdry}}$  is less than 95% of  $x_{\text{NOxref}}$ , repair or replace the chiller.

(e) *Exceptions.* The following exceptions apply:

(1) You may omit this verification if you can show by engineering analysis that for your NO<sub>x</sub> sampling system and your emission calculations procedures, the chiller always affects your brake-specific NO<sub>x</sub> emission results by less than 0.5% of the applicable NO<sub>x</sub> standard.

(2) You may use a chiller that you determine does not meet this verification, as long as you try to correct the problem and the measurement deficiency does not adversely affect your ability to show that engines comply with all applicable emission standards.

[73 FR 37312, June 30, 2008, as amended at 79 FR 23771, Apr. 28, 2014]

**§ 1065.378 NO<sub>2</sub>-to-NO converter conversion verification.**

(a) *Scope and frequency.* If you use an analyzer that measures only NO to determine NO<sub>x</sub>, you must use an NO<sub>2</sub>-to-NO converter upstream of the analyzer. Perform this verification after installing the converter, after major maintenance and within 35 days before an emission test. This verification must be repeated at this frequency to verify that the catalytic activity of the NO<sub>2</sub>-to-NO converter has not deteriorated.

(b) *Measurement principles.* An NO<sub>2</sub>-to-NO converter allows an analyzer that measures only NO to determine total NO<sub>x</sub> by converting the NO<sub>2</sub> in exhaust to NO.

(c) *System requirements.* An NO<sub>2</sub>-to-NO converter must allow for measuring at least 95% of the total NO<sub>2</sub> at the maximum expected concentration of NO<sub>2</sub>.

(d) *Procedure.* Use the following procedure to verify the performance of a NO<sub>2</sub>-to-NO converter:

(1) *Instrument setup.* Follow the analyzer and NO<sub>2</sub>-to-NO converter manufacturers' start-up and operating instructions. Adjust the analyzer and converter as needed to optimize performance.

(2) *Equipment setup.* Connect an ozonator's inlet to a zero-air or oxygen source and connect its outlet to one port of a three-way tee fitting. Connect an NO span gas to another port, and connect the NO<sub>2</sub>-to-NO converter inlet to the last port.

(3) *Adjustments and data collection.* Perform this check as follows:

(i) Set ozonator air off, turn ozonator power off, and set the analyzer to NO mode. Allow for stabilization, accounting only for transport delays and instrument response.

(ii) Use an NO concentration that is representative of the peak total NO<sub>x</sub> concentration expected during testing. The NO<sub>2</sub> content of the gas mixture shall be less than 5% of the NO concentration. Record the concentration of NO by calculating the mean of 30 seconds of sampled data from the analyzer and record this value as  $x_{\text{NOref}}$ .

(iii) Turn on the ozonator O<sub>2</sub> supply and adjust the O<sub>2</sub> flow rate so the NO indicated by the analyzer is about 10 percent less than  $x_{\text{NOref}}$ . Record the concentration of NO by calculating the mean of 30 seconds of sampled data from the analyzer and record this value as  $x_{\text{NO} + \text{O}_2\text{mix}}$ .

(iv) Switch the ozonator on and adjust the ozone generation rate so the

NO measured by the analyzer is 20 percent of  $x_{\text{NOref}}$  or a value which would simulate the maximum concentration of NO<sub>2</sub> expected during testing, while maintaining at least 10 percent unreacted NO. This ensures that the ozonator is generating NO<sub>2</sub> at the maximum concentration expected during testing. Record the concentration of NO by calculating the mean of 30 seconds of sampled data from the analyzer and record this value as  $x_{\text{NOmeas}}$ .

(v) Switch the NO<sub>x</sub> analyzer to NO<sub>x</sub> mode and measure total NO<sub>x</sub>. Record the concentration of NO<sub>x</sub> by calculating the mean of 30 seconds of sampled data from the analyzer and record this value as  $x_{\text{NOxmeas}}$ .

(vi) Switch off the ozonator but maintain gas flow through the system. The NO<sub>x</sub> analyzer will indicate the NO<sub>x</sub> in the NO + O<sub>2</sub> mixture. Record the concentration of NO<sub>x</sub> by calculating the mean of 30 seconds of sampled data from the analyzer and record this value as  $x_{\text{NOx} + \text{O}_2\text{mix}}$ .

(vii) Turn off the ozonator O<sub>2</sub> supply. The NO<sub>x</sub> analyzer will indicate the NO<sub>x</sub> in the original NO-in-N<sub>2</sub> mixture. Record the concentration of NO<sub>x</sub> by calculating the mean of 30 seconds of sampled data from the analyzer and record this value as  $x_{\text{NOxref}}$ . This value should be no more than 5 percent above the  $x_{\text{NOref}}$  value.

(4) *Performance evaluation.* Calculate the efficiency of the NO<sub>x</sub> converter by substituting the concentrations obtained into the following equation:

$$\text{efficiency} = \left( 1 + \frac{x_{\text{NOxmeas}} - x_{\text{NOx} + \text{O}_2\text{mix}}}{x_{\text{NO} + \text{O}_2\text{mix}} - x_{\text{NOmeas}}} \right) \cdot 100\%$$

(5) If the result is less than 95%, repair or replace the NO<sub>2</sub>-to-NO converter.

(e) *Exceptions.* The following exceptions apply:

(1) You may omit this verification if you can show by engineering analysis that for your NO<sub>x</sub> sampling system and your emission calculations procedures, the converter always affects your brake-specific NO<sub>x</sub> emission results by

less than 0.5% of the applicable NO<sub>x</sub> standard.

[70 FR 40516, July 13, 2005, as amended at 73 FR 37313, June 30, 2008; 73 FR 59330, Oct. 8, 2008; 76 FR 57447, Sept. 15, 2011]

## PM MEASUREMENTS

**§ 1065.390 PM balance verifications and weighing process verification.**

(a) *Scope and frequency.* This section describes three verifications.

(1) Independent verification of PM balance performance within 370 days before weighing any filter.

(2) Zero and span the balance within 12 h before weighing any filter.

(3) Verify that the mass determination of reference filters before and after a filter weighing session are less than a specified tolerance.

(b) *Independent verification.* Have the balance manufacturer (or a representative approved by the balance manufacturer) verify the balance performance within 370 days of testing.

(c) *Zeroing and spanning.* You must verify balance performance by zeroing and spanning it with at least one calibration weight, and any weights you use must that meet the specifications in § 1065.790 to perform this verification.

(1) Use a manual procedure in which you zero the balance and span the balance with at least one calibration weight. If you normally use mean values by repeating the weighing process to improve the accuracy and precision of PM measurements, use the same process to verify balance performance.

(2) You may use an automated procedure to verify balance performance. For example many balances have internal calibration weights that are used automatically to verify balance performance.

(d) *Reference sample weighing.* Verify all mass readings during a weighing session by weighing reference PM sample media (e.g., filters) before and after a weighing session. A weighing session may be as short as desired, but no longer than 80 hours, and may include both pre-test and post-test mass readings. We recommend that weighing sessions be eight hours or less. Successive mass determinations of each reference PM sample media (e.g., filter) must return the same value within  $\pm 10 \mu\text{g}$  or  $\pm 10\%$  of the net PM mass expected at the standard (if known), whichever is higher. If successive reference PM sample media (e.g., filter) weighing events fail this criterion, invalidate all indi-

vidual test media (e.g., filter) mass readings occurring between the successive reference media (e.g., filter) mass determinations. You may reweigh these media (e.g., filter) in another weighing session. If you invalidate a pre-test media (e.g., filter) mass determination, that test interval is void. Perform this verification as follows:

(1) Keep at least two samples of unused PM sample media (e.g., filters) in the PM-stabilization environment. Use these as references. If you collect PM with filters, select unused filters of the same material and size for use as references. You may periodically replace references, using good engineering judgment.

(2) Stabilize references in the PM stabilization environment. Consider references stabilized if they have been in the PM-stabilization environment for a minimum of 30 min, and the PM-stabilization environment has been within the specifications of § 1065.190(d) for at least the preceding 60 min.

(3) Exercise the balance several times with a reference sample. We recommend weighing ten samples without recording the values.

(4) Zero and span the balance. Using good engineering judgment, place a test mass such as a calibration weight on the balance, then remove it. After spanning, confirm that the balance returns to a zero reading within the normal stabilization time.

(5) Weigh each of the reference media (e.g., filters) and record their masses. We recommend using substitution weighing as described in § 1065.590(j). If you normally use mean values by repeating the weighing process to improve the accuracy and precision of the reference media (e.g., filter) mass, you must use mean values of sample media (e.g., filter) masses.

(6) Record the balance environment dewpoint, ambient temperature, and atmospheric pressure.

(7) Use the recorded ambient conditions to correct results for buoyancy as described in § 1065.690. Record the buoyancy-corrected mass of each of the references.